

MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

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No. 6.

PROFESSOR ADAMS, F.R.S., in the Chair.

Edward Hamilton Pringle, Esq., Madras ;
John Dyer, Esq., Rokeby Road, New Cross ;
Robert Kalley Miller, Esq., Royal Naval College, Greenwich ;
Rev. James Pearson, Fleetwood ; and
Mortimer Evans, Esq., Glasgow,

were balloted for and duly elected Fellows of the Society.

A proposal has been communicated to the Council for placing, in Westminster Abbey or elsewhere, a Memorial to Jeremiah Horrox, the first observer of a transit of *Venus*. The President intended to mention this at the evening meeting, but inadvertently omitted to do so.

Dry Plate Process for Solar Photography. By Capt. W. de W. Abney, R.E.

Before commencing the preparation of the plates, some fresh eggs (say four for a dozen medium sized plates) are procured, and the whites carefully beaten up (with one drachm of liquid ammonia to each white) by a whisk, a bundle of quill pens, or by shaking in a bottle, into which fragments of glass have been introduced. When the froth has subsided, the clear fluid is procured by filtering through muslin, and is placed in a bottle labelled A. A glass of bitter or mild ale is next obtained, and to half of it (which should be 5 oz.) 10 grains of pyrogallic acid

are added, and the solution, if necessary, is filtered through filter-paper. This is lettered P. The other 5 oz. of beer are placed in another bottle, and labelled B.

Should the fresh eggs not be obtainable, dried albumen may be used; 20 to 25 grains of the latter should be dissolved in an ounce of distilled water, and substituted for them.

Bottled beer may also be substituted for the ordinary bitter ale. Care should be taken that, by a gentle heat, the carbonic acid is all liberated, otherwise carbonate of ammonia will be formed on the addition of alkaline albumen.

(i.) Any ordinary collodion will answer. The bromo-iodized sample, supplied by Thomas of Pall Mall, with 2 grains of pyroxyline added to each ounce, gives very rapid results.

For sun pictures, however, a modification is advisable; and much will depend on the climate in which it has to be employed.

(ii.) For a cold climate, collodion made by the following formula will be found to give good results:—

Thomas's bromized collodion	. . .	20 oz.
„ ordinary bromo-iodized	. . .	20 oz.
Plain collodion, <i>not</i> iodized	. . .	6 oz.
Pyroxyline		276 grains.
Water		400 minims.

(iii.) For warmer climates the following will be found to answer better:—

Thomas's bromized collodion	. . .	20 oz.
„ bromo-iodized	. . .	20 oz.
* Alcohol, S. G. .850	. . .	6 to 8 oz.
Pyroxyline		300 grains.
Water		120 minims.

With (i.) the ordinary nitrate of silver bath, 40 grains to the ounce, is used. If greater sensitiveness is required, 10 grains of nitrate of uranium to each fluid ounce of the above are added.

With (ii.) and (iii.) the above bath should be used, together with another made 60 grains to the ounce of water.

A substratum to the collodion is recommended to insure adhesion of the film to the glass plate during development. This is made by mixing the white of one egg with 40 oz. of distilled water, and applying it to the surface of the plate by a piece of swan's down, calico, or flannel, folded over the edge of a strip of glass and used as a brush. The brush is dipped in the fluid, and drawn down the plate in parallel lines till the whole surface has received a coating. Here I may mention that a *clean* plate is necessary; but much polishing with a silk handkerchief or chamois prevents the substratum taking kindly to the glass.

* The hotter the climate, the more alcohol will be required.

Another substratum, which seems to give almost better results than the albumen, may be substituted for the above:—

Sheet gelatine	75 grains.
Distilled water	60 oz.
Ammonia	$\frac{1}{4}$ oz.
Alcohol	1 oz.

The gelatine should be softened in 30 oz. of cold water, and then dissolved by 30 oz. of boiling water. When cold, the remaining ingredients should be added.

If a plate (after the substratum has been thoroughly dried) is coated with collodion (i.), it is sensitized in the ordinary manner in the 40-grain bath, *i.e.*, for about 4 minutes in cold to $2\frac{1}{2}$ in warm weather. If the plate has been coated with (ii.) or (iii.), it is plunged in the 40-grain bath and kept there till all "greasiness" has disappeared. It is then transferred to the 60-grain bath, and kept there for 7 or 8 minutes longer, *i.e.*, until a creamy film is obtained. The plate is next plunged into distilled water, or spring water which has been rendered slightly alkaline by adding a few drops of ammonia to it (if iron be present as an impurity), and to which, *after boiling and filtering*, a few drops of nitric acid have been added to restore neutrality. When the "greasiness" has disappeared from the film, the plate may be washed under the tap for a minute, or in different dishes of water, until all free nitrate of silver is got rid of. (This may be effected rapidly by adding a pinch or two of common salt to the last washing water but one in the dishes.) In a small tumbler are next mixed equal quantities of A and B, stirred up with a glass rod, and floated over the washed film. If all the nitrate have not been washed away, stains may here become manifest. This solution is kept on half a minute, and is then poured off. The plate is once more thoroughly washed, and solution P is floated over for another half minute. The plate is then set up on one corner to dry spontaneously. Before being stored away, the last trace of moisture may be expelled by gently warming over a stove or Bunsen burner. In dry climates this precaution need not be taken. As a rule, the plate requires no "backing" to prevent blurring of the image, but if it appear very transparent a backing may be necessary. Cartridge-paper stained with any red dye (alkaline aurine will answer), and coated with gum and flour stained of the same colour, will give what is required. When damped, the paper will adhere to the back of the plate, and dry in optical contact with it. It can easily be removed by wetting.

The exposure is the same as that necessary for a wet plate prepared with the same collodion, though no damage will be done to the picture if six times that amount be given. With the uranium-bath the dry plate is quicker than a wet plate.

The development need not take place for a month after exposure. The following solutions must be made up:—

No. I.	{ pyrogalllic acid . . .	12 grains.
	{ water . . .	1 oz.
No. II.	{ liquor ammonia . . .	1 part.
	{ water . . .	4 parts.
No. III.	{ citric acid . . .	60 grains.
	{ glacial acetic acid . . .	30 minims.
	{ water . . .	1 oz.
No. IV.	{ nitrate of silver . . .	20 grains.
	{ water . . .	1 oz.

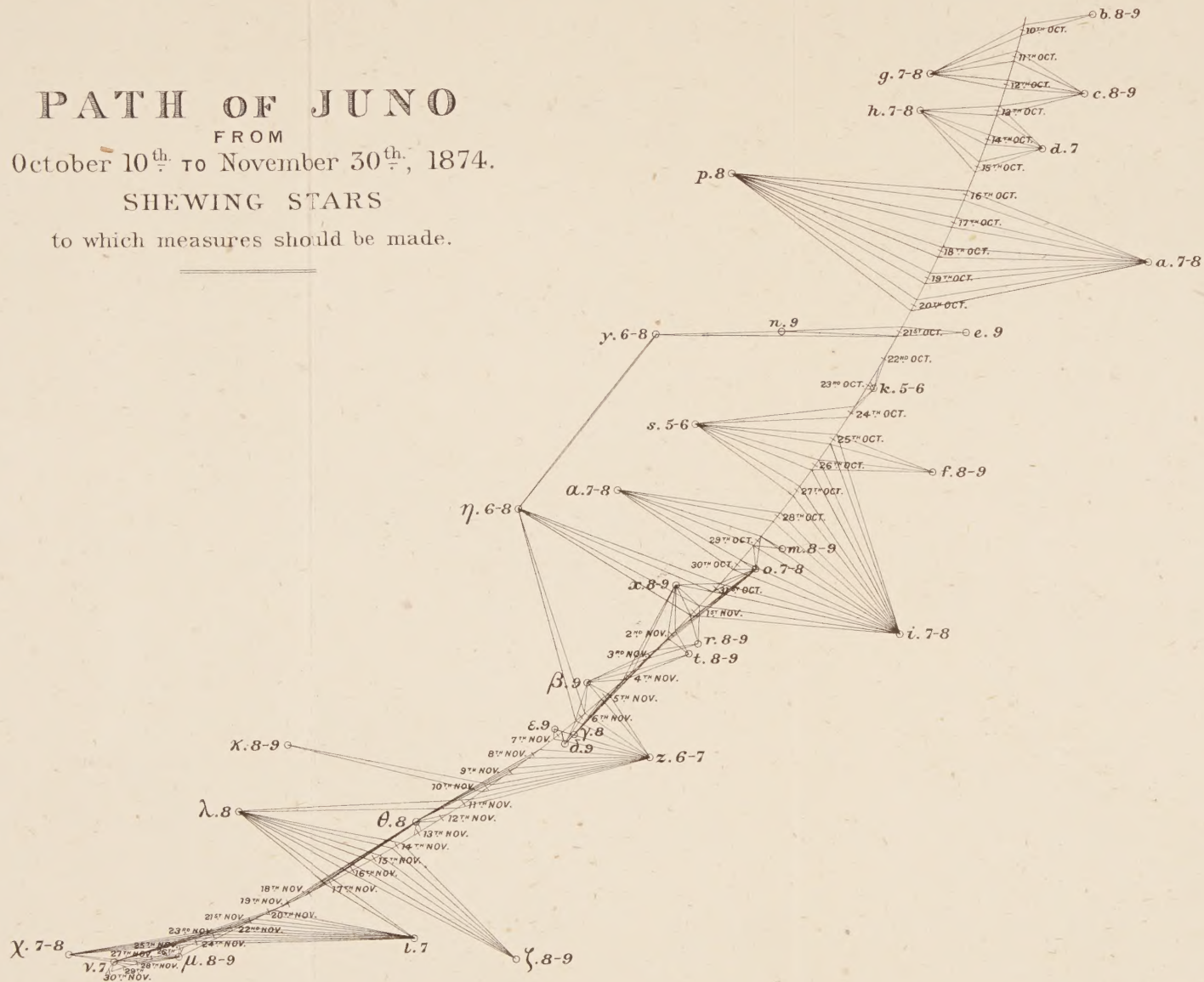
The plate is washed in spring or rain water of a not less temperature than 60° F. till all the beer has been removed. Sufficient of No. I. is taken to well cover the plate, and first flowed over it. Into the developing cup are then dropped three drops of No. II., and No. I. is poured off the plate on to it. The solution is then flowed over the plate again, and after a few seconds the detail will begin to appear by *reflected* light. As detail appears, another two drops of No. II. may be added, and so on, till *nearly* all the detail is visible. The plate is now washed in water of the same temperature. Here it may be remarked that stronger doses of No. II. may be used to under-exposed pictures. Six drops of No. III. are next dropped into a clean developing cup, and the same quantity of No. I. added as before. This is flowed over the plate to neutralise any trace of ammonia remaining. Into the cup are now dropped two drops of No. IV., the pyro-solution from the plate poured on to it, and once more applied to the film. The image will gradually acquire strength, the remaining detail appearing. The intensity is gained by adding to the same, or fresh (*acid*) pyro-solution more silver (No. IV.) When the image appears of sufficient density, it is fixed with a solution of hyposulphite of soda or cyanide of potassium. In the case where the plate is backed, the film should be wetted first, and then the paper removed.

The alkaline development produces a faint image by the reduction of the organic salt and bromide of silver to the suboxide of silver. The iodide is unattacked by it. The acid silver development utilises the exposed iodide thus: the attraction of the suboxide for fresh silver (deposited by the acid development) is increased by the irritated iodide, and thus density is acquired.

It will be noticed that no restrainer, such as bromide of potassium, is used with the alkaline development. The albumen dissolved by the ammonia plays the part of a retarder, but not of a destroyer. Thus the image is well under control.

An *under*-exposed picture has an image of slate colour; an *over*-exposed picture has one of an olive green; whilst one properly exposed is of a rich chocolate brown. Every plate sufficiently exposed will yield a good negative.

PATH OF JUNO
 FROM
 October 10th to November 30th, 1874.
SHEWING STARS
 to which measures should be made.



On the Determination of the Solar Parallax by Observations of Juno at Opposition. By Lord Lindsay and Mr. David Gill.

Dr. Galle has already proposed (*Astron. Nach.*, vol. lxxx. p. 1), a method of obtaining the solar parallax, by observing, with a wire micrometer simultaneously at a northern and southern observatory, the difference of declination between a minor planet and two stars near the planet, and nearly equally north and south from it.

The method recommends itself, not by a favourable factor of parallax such as is afforded by a transit of *Venus* or a favourable opposition of *Mars*, but by the extreme precision with which a minute point of light can be bisected as compared with that with which a web can be brought into contact with a disk.

We are not aware that any results have been published of the application of the method, though there is no doubt that it is capable of great accuracy.

It has appeared to us that if we can select suitable stars, and observe the parallactic displacement of a minor planet relative to these stars by the Earth's rotation, we have a method of determining the solar parallax, which is free from the difficulties and disappointments attending observations in which co-operation is necessary, and where the most complete arrangements and perfect observation may be upset by unfavourable weather at the opposite station.

The accuracy of the proposed method will depend—

1. On the amount of displacement that can be measured.
2. The accuracy with which the measures can be made.
3. The number of nights on which the measures can be repeated, which will partly depend on the nights on which suitably situated stars of comparison can be found.

The planet *Juno* at the opposition of 1874 appears to be very favourably situated for a trial of this method. Mauritius (the station where we observe the transit of *Venus*) a suitable position, and the Repsold Heliumeter, with which the transit is to be observed, a suitable instrument. We have accordingly investigated the conditions of probable attainable accuracy as follows, and trust the results may be acceptable to the Society.

Juno, in opposition on 5th November, 1874, has a horizontal parallax of $8''.7$, and south declination of $3^{\circ}50'$.

If we suppose that we may begin to measure when the planet has an altitude of 20° , and continue till the altitude is 40° ; and at setting begin to measure at an altitude of 40° , and observe till the planet's altitude is 20° : then for opposition we have—

Altitude.	Parallax in A.R.	Hour Angle.
°	"	h m
20	7.70	4 41
30	7.05	
40	6.14	3 15

Time available for observation 1 26

In other words, we shall be able to observe a displacement of about 14", and have 86 minutes both at rising and setting during which we may make observations.

The observations can be made with advantage for a month preceding and a month following opposition.

It will not be possible to observe the planet at so large an hour angle in the early mornings a month before opposition, as the sun rises when the hour angle of the planet is about three hours and a half; nor similarly a month after opposition shall we be able to commence observation so early as is desirable, and moreover the horizontal parallax will be a little less. Notwithstanding this, for fifty nights an average parallactic displacement in A.R. of about 12" can be obtained.

In the list of stars which we have prepared for comparison with *Juno*, distances will be found considerably exceeding those usually measured with the heliometer.

So far as we know, *Bessel* seldom, if ever, measured distances equal to 3000", and at Oxford the greatest distances measured with the heliometer have been under that amount.

In the Königsberg heliometer (*Bessel's*), the divided lenses being mounted in plain slides, distortion of the image resulted when large angles had to be measured; but in the construction of the new Repsold heliometer, as also in the Oxford heliometer by the same makers, the lenses move in slides of circular curvature in the direction of their length, the centre of curvature being the focal point of the object-glass.

The effect of this arrangement is, that whatever the separation of the segments of the object-glass, the images are equally free from distortion, and so far as the optical qualities of the instrument are concerned, a large angle can be measured with equal accuracy with a small one.

In the use of the Oxford heliometer, as in the Königsberg instrument, one segment of the object-glass remains fixed, and the other is used for measurement on opposite sides of the fixed segment.

In this way the extent of angle which the instrument is capable of measuring is limited by the amount which one segment can be moved on either side of zero.

In the more modern form of the Repsold heliometer* both

* Astronomy is indebted to Drs. Struve, Auwers, and Winnecke for the arrangement of this instrument. Similar heliometers are to be employed by Russia for observation of the transit of *Venus*.

halves of the divided object-glass are moved in equal and opposite directions by a single movement, and thus the extent of angle which can be measured is doubled, and the instrument can measure completely an angle of 2° .

The symmetry thus given to the observation also facilitates the reduction of the observations and adds to their accuracy, but to this we need not further allude at present. It will be sufficient to show with what precision such angles can be measured, and what precautions are necessary to attain the highest possible accuracy.

In illustration, we give the following observations recently made by Mr. Gill, at Dunecht Observatory, on a zone of stars in *Perseus* * to determine the value of the scale of the instrument, the distances and magnitudes of the stars being very similar to those which occur in the list of stars to be measured with *Juno*.

The *first* column contains the date of observation.

The *second*, the hour angle of observation.

The *third*, the distance converted into arc on an assumed approximate value of the heliometer scale.

The *fourth*, the sum of the corrections for aberration and refraction (the effect of the barometer and thermometer on the refraction has been included).

The *fifth*, the resulting distance.

The *sixth*, the mean of each successive pair of observations which constitute a *complete* measure. (See note * on next page.)

The *seventh*, the difference of the *complete* observation from the mean of the *complete* observations of the same evening.

The *eighth*, the difference from the mean of all the observations of the same object.

The *ninth*, the temperature at the time of observation.

* The stars are as follow:—

	Mag.	A.R.			Decl.	
		h	m	s	$^\circ$	'
<i>a</i>	6.8	3	8	55	+40	1.2
<i>b</i>	7.5	3	5	53	39	37.7
<i>c</i>	5.2	3	3	7	39	7.9
<i>d</i>	8.1	2	59	26	38	34.9
<i>e</i>	5 var.	2	57	4	38	20.8
<i>f</i>	6.8	2	53	50	38	23.8
<i>g</i>	6.0	2	50	2	38	5.7
<i>h</i>	6.0	2	45	44	37	49.3
<i>i</i>	4.8	2	42	36	37	47.2
<i>k</i>	7.0	2	39	35	37	16.2

The successive distances and position-angles of these stars having been measured, the distances are projected on the great circle joining the extreme stars, and the result so obtained is compared with the distance obtained by Meridian observation of the extreme stars. The same stars have been observed by the German heliometer observers of the transit of *Venus*. The same

c—e

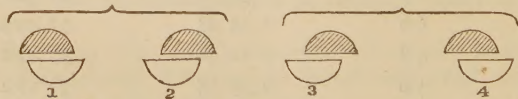
I. Date.	II. Hour Angle.	III. Observed Distance.	IV. Correction for Refrac- tion and Aberration.	V. Resulting Distance.	VI.	VII.	VIII.	IX.
	h m	"	"	"	"	"	"	° '
Feb. 3	1 10.3	5094.811	+1.663	5096.474	5096.276	...	0.358	38 3
	1 19.5	5094.386	1.691	5096.077				
Feb. 10	3 13.9	5094.669	2.261	5096.930	5096.774	0.022	0.140	29 0
	3 23.0	5094.286	2.331	5096.617				
	3 33.3	5094.095	2.423	5096.518	5096.818	0.022	0.184	
	3 39.8	5094.582	2.536	5097.118				
Feb. 16	2 36.9	5094.618	1.897	5096.515	5096.564	0.141	0.070	40 0
	2 43.5	5094.677	1.935	5096.612				
	2 57.5	5094.360	2.017	5096.377	5096.282	0.141	0.352	
	3 4.0	5094.131	2.055	5096.186				
Feb. 19	2 22.5	5095.202	1.885	5097.087	5096.913	0.050	0.279	40 5
	2 29.0	5094.826	1.913	5096.739				
	3 26.5	5094.710	2.282	5096.992	5096.814	0.050	0.180	38 0
	3 32.5	5094.301	2.335	5096.636				

e—g

Feb. 10	1 33.0	5061.521	-1.628	5063.149 ⁵	5063.063	0.099	0.066	28 0
	1 40.7	5061.328	1.648	5062.976 ⁸				
	1 53.5	5061.925	1.689	5063.614	5063.261	0.099	0.264	
	2 1.2	5061.210	1.698	5062.908				
Feb. 13	2 28.1	5061.223	1.678	5062.901	5063.022	0.136	0.025	40 2
	2 36.9	5061.421	1.721	5063.142				
	2 46.1	5061.151	1.748	5062.899	5062.750	0.136	0.247	
	2 53.1	5060.824	1.777	5062.601				

places for the extreme stars will be assumed in the reductions, and the values of the scales of the heliometers so obtained will thus be strictly comparable, and a small absolute error in their values would have no effect on the transit of *Venus* observations. The star *a* has been rejected, as it is a difficult double star, and *b* to *k* are the extreme stars.

* The observations are made thus



with the halves of the object-glass as sketched. Observations 1 and 2 give one measure, and 3, 4 another; but as the zero of the microscope is continually changing from flexure, it is necessary to make the observations in this order to eliminate the effect of this change.

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Date.	Hour Angle.	Observed Distance.	Corr. for Refraction and Aberration.	Resulting Distance.				
	h m	"	"	"	"	"	"	° '
Feb. 18	3 48.2	5060.811	2.143	5062.954	5062.890	...	0.107	35 0
	3 55.0	5060.636	2.190	5062.826				

 $h-i$

Jan. 9	22 37.5	2226.448	+0.614	2227.062	2227.218	...	0.211	38 0
	22 56.1	2226.757	0.616	2227.373				
Jan. 24	0 36.2	2225.939	0.665	2226.604	2226.878	0.024	0.129	31 0
	0 45.7	2226.479	0.673	2227.152				
	1 3.9	2226.366	0.693	2227.059	2226.926	0.024	0.081	
	1 16.2	2226.095	0.697	2226.792				

 $g-h$

Jan. 9	23 26.5	3213.297	+0.908	3214.205	3214.400	0.168	0.044	39 0
	23 38.6	3213.685	0.909	3214.594				
	23 58.1	3213.438	0.914	3214.352	3214.063	0.168	0.293	
	0 9.8	3212.856	0.918	3213.774				
Jan. 24	1 35.0	3213.029	1.055	3214.084	3214.147	0.227	0.209	30 7
	1 44.3	3213.139	1.070	3214.209				
	1 55.5	3213.477	1.093	3214.570	3214.600	0.227	0.244	
	2 5.8	3213.508	1.121	3214.629				
Feb. 16	3 55.0	3213.379	1.463	3214.842	3214.568	...	0.212	39 8
	4 5.9	3212.766	1.527	3214.293				

 $h-k$

Feb. 10	2 32.8	4841.915	+1.868	4843.783	4843.766	0.089	0.428	28 0
	2 42.8	4841.828	1.921	4843.749				
	2 58.3	4841.380	2.013	4843.393	4843.589	0.089	0.605	
	3 6.9	4841.715	2.070	4843.785				
Feb. 13	4 21.7	4841.424	2.575	4843.999	4844.195	...	0.001	41 3
	4 28.1	4841.735	2.656	4844.391				
Feb. 16	4 32.5	4842.309	2.719	4845.028	4844.546	0.165	0.352	39 0
	4 41.3	4841.202	2.861	4844.063				
	4 52.3	4842.664	3.065	4845.729	4844.876	0.165	0.682	
	5 2.2	4840.742	3.280	4844.022				

 $b-c$

Jan. 4	0 47.9	2683.868	+0.867	2684.735	2684.937	0.013	0.149	31 0
	1 0.9	2684.260	0.878	2685.138				

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Date.	Hour Angle.	Observed Distance.	Corr. for Refraction and Aberration.	Resulting Distance.				
	h m	"	"	"	"	"	"	o "
Feb. 3	1 20.6	2684.131	0.899	2685.030	2684.962	0.013	0.124	38 0
	1 37.3	2683.964	0.930	2684.894				
	1 36.8	2684.528	0.923	2685.451	2685.440	0.097	0.354	
	1 44.5	2684.489	0.940	2685.429				
	1 54.0	2683.660	0.958	2684.618	2685.247	0.097	0.162	
2 0.3	2684.903	0.972	2685.875					
Feb. 28	2 53.4	2683.940	1.082	2685.022	2684.942	0.022	0.144	41 0
	3 0.9	2683.753	1.108	2684.861				
	3 11.3	2684.038	1.142	2685.180	2684.985	0.022	0.101	
	3 19.0	2683.616	1.174	2684.790				

c—d

Feb. 3	2 28.0	3222.782	+ 1.246	3224.028	3223.494	0.054	37 6
	2 34.2	3221.693	1.266	3222.959			
	2 42.9	3222.710	1.296	3224.006	3223.602	0.054	
	2 52.8	3221.871	1.327	3223.198			

e—f

Jan. 9	1 28.5	2291.022	+0.677	2291.699	} 2291.465	0.202	0.303	38 0
	1 36.7	2290.551	0.680	2291.231				
	1 49.4	2290.865	0.689	2291.554	} 2291.869	0.202	0.101	
	2 0.4	2291.485	0.698	2292.183				
Jan. 25	1 56.1	2291.061	0.694	2291.755	} 2291.966	...	0.198	44 5
	2 12.4	2291.470	0.707	2292.177				
Feb. 4	0 10.1	2291.053	0.661	2291.714	} 2291.727	0.043	0.041	43 5
	0 19.4	2291.076	0.664	2291.740				
	0 49.6	2291.210	0.672	2291.882	} 2291.812	0.043	0.044	
	0 57.6	2291.068	0.674	2291.742				

f—g

Jan. 9	0 39.7	2863.227	+0.657	2863.884	} 2863.537	0.182	0.186	38 5
	0 48.2	2862.530	0.659	2863.189				
	1 5.3	2862.167	0.660	2862.827	} 2863.173	0.182	0.178	
	1 15.2	2862.849	0.669	2863.518				
Jan. 25	1 9.9	2862.471	0.665	2863.136	} 2863.464	0.117	0.113	44 5
	1 17.9	2863.122	0.670	2863.792				
	1 36.9	2862.484	0.682	2863.166	} 2863.231	0.117	0.120	
	1 45.3	2862.610	0.685	2863.295				

$d-e$

I.	II.	III.	IV.	V.				
Date.	Hour Angle.	Observed Distance.	Corr. for Refraction and Aberration.	Resulting Distance.	VI.	VII.	VIII.	IX.
	h m	"	"	"	"	"	"	"
Feb. 3	3 14.8	1885.239	+0.820	1886.059	1886.439	...	...	37 0
	3 22.1	1885.980	0.838	1886.818				

 $i-k$

Jan. 4	23 18.5	2905.021	+0.875	2905.896	2906.166	0.075	0.051	30 0
	23 33.1	2905.552	0.884	2906.436				
	23 50.9	2905.261	0.893	2906.154	2906.315	0.075	0.200	
	0 4.7	2905.572	0.904	2906.476				
Jan. 17	23 9.4	2905.166	0.842	2906.008	2905.953	0.093	0.162	32 0
	23 24.9	2905.045	0.852	2905.897				
	23 41.5	2904.697	0.860	2905.557	2905.769	0.093	0.346	
	23 54.0	2905.117	0.863	2905.980				
March 4	2 48.6	2905.209	1.195	2906.404	2906.361	0.169	0.246	47 3
	2 58.8	2905.081	1.237	2906.318				
	3 11.0	2904.728	1.295	2906.023	2906.124	0.169	0.009	
	3 18.6	2904.887	1.337	2906.224				

If we examine the seventh column, which contains the difference of each complete observation from the mean of the complete observations of the same evening, and compare these differences with those in the eighth column, where we have the difference of each complete observation from the mean of the whole observations made on the same stars, we find, as we should expect, that the observations of the same evening agree with each other much more closely than those of different evenings.

Dividing the stars into three groups, according to their distances, we find by the method of least squares the probable error from the residuals of column VII. between observations of the same object made within a short interval of each other, representing *very nearly* the probable error of *pointage* (which includes the error in making coincidence of the images of the stars and error in reading the scales *) and from the residuals in column VIII. the probable error of measure, including errors produced by temperature, &c., on different evenings. The results are:

* The error of runs is practically eliminated in the method of observation by observing the division which precedes as well as that which follows the zero of the microscope.

	Mean Distance. "	Probable Error by Column VII. "	Probable Error by Column VIII. "
Group I.	2401	0'069	0'123
Group II.	3052	0'088	0'137
Group III.	5001	0'081	0'220

We find from these "probable errors" a confirmation of what we previously stated, that the error of *pointage* is hardly affected by the distance of the objects, whilst the other errors of observation from night to night vary nearly proportionally with the distance between the stars.

It becomes important to consider very fully what are these sources of error which in the observation of stars of about 5000" distance increase the probable error of observation nearly three-fold.

The errors to which an observation with the heliometer is subject, beyond those of *pointage*, appear to be due to—1st, Temperature. 2nd. Maladjustment of the focal point. 3rd. Errors of division of the scales. 4th. Errors of the micrometer screw, used to subdivide the scale intervals. 5th. Error of the absolute value of the scale at the standard temperature.

Of these, we shall at present only deal with 1 and 2; 3 and 4 will also to a small extent affect the results, as two observations of the same evening are usually made with the position circle reversed, and the flexure of the tube as well as a small "loss of time" in the slow motion of the segments of the object-glass combine to change the zero of the microscope somewhat, and so a different part of the micrometer screw is used in the measures, and even sometimes another division. The investigation of the errors of the micrometer screw are not yet complete, but the effect of their application can only be to diminish very slightly the probable error. 5. Can only affect us where *absolute* results are required, and these do not enter into the question before us.

To obtain some first approximate idea of the temperature correction, we took the intervals of the stars observed at the highest temperature and compared them with the intervals of lowest temperature, as follows—dividing the observations into two series, one of double, the other of single intervals:

Distance. "	Temperature.	Distance. "	Temperature.	Difference.
5096'796	29 0 F.	5096'864	39 0 F.	+ '00133
5063'162	28 0 "	5062'886	40 2 "	- '00447
4843'678	28 0 "	4844'195	41 3 "	+ '00803
2226'902	31 0 "	2227'218	38 0 "	+ '02024
3214'397	30 7 "	3214'230	39 0 "	- '00614
2684'950	31 0 "	2684'964	41 0 "	+ '00052
2291'667	38 0 "	2291'770	43 5 "	+ '00814
2863'355	38 5 "	2863'348	44 5 "	- '00041
2906'241	30 0 "	2906'293	47 0 "	+ '00004

From these we obtain the following results, having regard to the distances and temperatures:

1st Series, effect of + 1° F. on 1000" distance	= + 0".00174
2nd Series, " " " "	= + 0".00189

It is evident, however, from inspection of the residuals that this close coincidence of results is greatly indebted to chance, and the only conclusion we can draw from it is that the temperature correction of the instrument is excessively small, and that a very much greater range of temperature than that afforded by the recent mild winter will be necessary to obtain this coefficient with the desirable accuracy.

If we consider in what way temperature affects the value of the heliometer scale, we shall see why this coefficient is so small. The value of the scale depends on the proportion which the length of the scale bears to the focal length of the telescope.

This scale being of silver the effect of temperature on it will be represented by the usual coefficient of expansion of that metal. The effect of temperature on the focal length of the object-glass has been measured as follows:—In the common focus of the object-glass and eye-piece are cross webs. To the frame carrying these webs is attached a scale, divided into $\frac{1}{10}$ of millimètres, and these divisions can be read by estimation to $\frac{1}{100}$ of a millimètre relative to a line engraved on a block attached to the brass tube of the telescope, so that the readings of the focal point by this scale at different temperatures give measures of the focal point relative to the brass tube of the instrument.

The following are the results of these measures:

Temperature.	No. of Obs.	Millim.
32–36 F.	23	7.940
38–42 "	41	7.937
42–48 "	21	7.934

The lengthening of the focus of the object by heat, is thus found to be practically equal to the expansion of the brass tube of the instrument.

This law appears to hold good with many instruments. Struve found the same with the Prime Vertical Transit at Pulkowa, and the German heliometer observers have found similar results with their instruments. The temperature coefficient of the instrument is therefore equal to—

(“coefficient of expansion of silver”)—(coefficient of expansion of brass).

If we take the coefficient of expansion for 1° F. for

Silver	= .00001060
Brass	= .00001044

the temperature coefficient of the instrument will be $+0.0000016$, or for our former unit of $1000'' = 0.00016$ for 1° F .

This quantity is so minute as to be almost insensible in the largest angles and greatest differences of temperature likely to be measured, amounting only to 0.00056 for a distance of $5000''$ and a difference of 70° from mean temperature. As the silver of the scale is probably alloyed with copper, whose expansion is lower than that of brass, it is probable that the expansion of the scale is somewhat less than we have assumed and the equality of expansion of the scale and tube even still more perfect.

It is quite otherwise, however, when there is a *difference* of temperature between the object-glass and scale: then the excess of the temperature of the scale over that of the object-glass will increase its value in direct proportion to the excess of temperature and coefficient of the scale's expansion. Thus, if the temperature of the scale exceeds that of the object-glass by 5° F . the increase of the value of the scale (that is, the diminution of its reading) is 0.00261 on a distance of $5000''$.

We shall now examine the effects of the maladjustment of the focus.

Suppose a measure correctly made at the proper focus, let s be the distance observed, f the focal length of the heliometer. If we now suppose the observer's eye to have no accommodation and remove the eye-piece from the object-glass by a very small amount $= \frac{f}{n}$, we shall disturb the coincidence of the images, and to restore that coincidence shall have to separate the divided segments still further by an amount $= \frac{s}{n}$, so that for an observation where the focal point is too great by an amount $= \frac{f}{n}$, the correction will be $= -\frac{s}{n} \dots \dots \dots (1)$.

As in observations of stars there is generally little difference between the temperature of the object-glass and that of the tube, it has been usual to make all the measures using the same readings of the focal scale, so that the position of the focal point with respect to the cross webs depends on the difference in temperature of the tube and object-glass.

If we denote—

t^o = temperature of the object-glass,

t^s = „ „ „ scale,

t^t = „ „ „ tube,

t = normal temperature at which the focal point is adjusted and scale value determined,

x = coefficient of expansion of scale,

y = „ „ „ „ tube,

z = lengthening of focal length of object-glass by 1° F .,

s = distance measured,

we shall have—

Correction for temperature of scale = $+ x (t^s - t) s$.

If we put $x = y + \Delta y$,

The correction becomes = $-y (t^s - t) s + \Delta y (t^s - t) s \dots (2)$.

The correction for temperature of the object-glass is = $-z (t^s - t) s$.

But since $z = y$ the correction may be written = $-y (t^s - t) s \dots (3)$.

Since the focal point is adjusted for temperature t , we must employ a correction for the displacement.

The increase of the length of the tube is $f (t^t - t) y$.

And that of the focus of object-glass

$$= f (t^s - t) z = f (t^s - t) y.$$

The difference is the distance which the eye-piece will be removed beyond the focal point $\left(\frac{f}{n}\right) = f (t^t - t^s) y$.

But by (1) the correction for $\frac{f}{n} = -\frac{s}{n}$.

Hence the correction for displacement of focus becomes $-y s (t^t - t^s) \dots (4)$.

The sum of these corrections, 2, 3, and 4, is the correction to be applied to an observation.

$$2 = -s y t^s + s y t$$

$$3 = +s y t^s - s y t + \Delta y \cdot (t^s - t) s$$

$$4 = -s y t^t + s y t^s$$

The sum of which is—

$$s y (t^s - t^t) + \Delta y (t^s - t) s$$

Thus we see it is only necessary to observe the temperatures of the scale and tube in order to eliminate all the effects of temperature on the measures, *if we assume that the eye has no accommodation.*

This could almost be done for very minute quantities if we could illuminate the field, and focus the eye on the wires immediately before measuring; but in the measurement of 8th and 9th magnitude stars it is necessary to employ a perfectly dark field. Some small systematic errors therefore creep in on this account, and it will be necessary so to arrange the stars of comparison and the order of observation that this may be eliminated as far as possible.

In constructing the following list we have endeavoured to select stars of nearly equal declination, and equally opposite A.R. from the planet, and sufficiently bright for observation. If this condition could be fulfilled in every case, the observations would be subject to no systematic error. It is intended, both at rising and setting, to make first one *complete* comparison with the star preceding the planet, next one with the star following, again another with the star following, and finally one with the star

preceding. In this way the effect of any constantly increasing instrumental change will be completely eliminated. The effect of a minute change in the value of the scale between rising and setting will be to give too large a parallax by one of the stars, and too small a parallax by the other, the mean would be free from systematic error. It has, of course, been impossible to select stars strictly fulfilling this condition; generally, at least, the stars are on nearly exactly opposite sides of the planet, though not exactly in the same parallel of A.R., in which case the parallactic displacement will depend to some extent on the position-angles. If the stars are strictly opposite and equally distant from the planet, a change of zero of the position circle is completely eliminated in the mean result. A glance at the accompanying map will show how we have endeavoured to overcome systematic errors by the arrangement of the stars of comparison. On several occasions where the star is very close to the planet, the systematic error must be so small that it has been thought better to measure only one very small distance rather than two very great and nearly opposite distances.

In order to eliminate the effect of an unknown error of the equatoreal adjustment on the position-angles, two meridian marks placed in the focus of lenses of long focus will be employed, one for "telescope following," and one for "telescope preceding."

The declination axis being levelled by a spirit level, a single observation of each mark will give the azimuth and altitude of the pole of the instrument (the azimuth and inclination of the collimator and the horizontal flexure of the heliometer being known).

The error of zero of the position circle will be obtained by separating the lenses, and bringing the image of the collimating mark to bisect successively the cross webs, when the heliometer is turned on the declination axis: this observation should be made with the tube on both sides of the polar axis.

By these precautions it is believed that when the distance is small, the parallax determined by the position-angles will be equally reliable with that obtained from the distances; particularly as in small stars the elongation of the images produced by division of the object-glass is hardly perceptible.

There are still two sources of systematic error which must be carefully eliminated: the *first* arises from an error in the assumed motion of the planet; the *second* from the errors of division of the scale and the errors of the micrometer screw, since by the motion of the planet different divisions will be employed at rising and setting.

With regard to the *first* of these, we are assured by Mr. Hind that it will be possible, by the existing observations of the planet, so to correct the present tables that not the smallest error is to be feared from this cause.

With regard to the *second*, it is not necessary for our purpose to ascertain the *absolute* division error of every interval. The division errors of our heliometer scale, as we shall presently

show, have been investigated for all divisions which occur in the measurement of angles up to $40'$, with every desirable accuracy, so that it will only be necessary to compare the divisions passed over during the night's observation with several divisions whose interval is known.

The errors of the screw are now being investigated in a manner similar to that so successfully employed by the late Prof. Kaiser at Leiden, and though the results are not yet completed, there is no doubt it is simply a question of time and care to ascertain these errors with any accuracy that is required.

In the determination of errors to which we have alluded, a portion of each scale from division 50 to division 98 has been selected.

In the moveable wire frame of the micrometer Mr. Simms inserted at our request double webs as follow :



The space from a to b being slightly less than twelve divisions, and that from c to d slightly less than six divisions.

The first process was to subdivide each scale into four parts of twelve divisions each : the interval of a twelve-division interval exceeding the interval $a b$ by an amount $= n^1 n^2 n^3 n^4$ successively. Then the true length of a 4th part of scale A will be $a b + \frac{n^1 + n^2 + n^3 + n^4}{4}$: the difference of $a (b + n^1)$ from a 4th part of scale A is the excess of the length of the interval 50-62 over $\frac{\text{Scale A}}{4}$.

In Table I., 1st, 2nd, 5th series, column 1, will be found these excesses of the intervals found by different series of observations in terms of the micrometer screw. The same point of the screw being used throughout, no error will result from this cause : the weights depend partly on the number of observations, and partly on the method of making the observations ; but as the full details will afterwards be published, we need not further allude to them at present.

The results of the 5th and 7th series are derived from observations made with the wires of interval $c d$, that is, by dividing the scale into 8 parts : the weight of this series has been made one half the other, in proportion to the number of observations. We believe this weight should be still less.

Column 2 gives the difference from mean in *seconds of arc*,

and the accuracy of the observations may be judged of from the amount of these residuals.

Table II. similarly exhibits the results of subdivision into intervals of six divisions; and Table III. that of subdivision into intervals of three divisions: in the case of the latter, instead of the residuals, we give the probable error of the bisection of the interval of six divisions in *seconds of arc*.

From these we obtain the successive division errors for each third division reckoned from 50 towards 98, in seconds of arc,*

$$\text{Scale A } 0.000 + 0''.162 + 0''.242 + 0''.017 + 0''.205 + 0''.242 + 0''.266 + 0''.315 \\ + 0''.013 + 0''.113 + 0''.168 + 0''.117 + 0''.108 - 0''.048 - 0''.027 - 0''.038 : 0.000.$$

$$\text{Scale B } 0.000 - 0''.060 + 0''.113 + 0''.138 + 0''.010 + 0''.088 + 0''.161 + 0''.027 \\ + 0''.152 + 0''.074 + 0''.212 + 0''.217 - 0''.662 - 0''.062 - 0''.021 + 0''.011 \pm 0.000.$$

If we look at these division errors, we see how very beautifully the scales are divided, and yet how much in a delicate enquiry like the present our systematic errors would be increased by disregarding them.†

We cannot pretend to predict what the probable error of a series of observations on the parallax of *Juno* will be, but if on 25 nights we can determine, as we believe we can, the place of the planet to $0''.1$, the resultant error in the solar parallax will be about

$$\frac{\frac{8.9}{12} \times 0''.1}{\sqrt{25}} = 0''.017$$

and we believe that this method is capable, with the precautions we have given, to give a result exceeding in accuracy that by any other method, if a sufficient number of observations on a number of different planets could be obtained.

* 1 Division is equal to 2 revolutions of the micrometer screw, and 1 revolution of the micrometer screw is approximately = $25''.74$.

† We have been led to give more fully than we otherwise should have done in the present paper some account of the determination of these division errors, from a remark of the Astronomer Royal, contained in his Report to the Board of Visitors, read June 3, 1873. Sir George Airy says, "My present impression is one of doubt on the certainty of equality of the parts of the scale employed." If we take even the uncorrected scale the probable error of a division hardly exceeds that of an error of four seconds of time in an observation of contact in the transit of *Venus*, and the fact that eight divisions are used in each measurement diminishes the probable error to a much smaller amount. We have not had time to fully compute the probable error of determination of the division error of each scale, but Tables I., II., and III. show it cannot exceed 2 or 3 hundredth parts of a second of arc.

Excesses of Division Intervals.

Scale A. TABLE I.									
		50-62		62-74		74-86		86-98	
	Weight	1	2	1	2	1	2	1	2
1st series	12	+0107	0"069	-0080	0"013	+0032	0"013	-0059	0"044
2nd series	12	+0085	0"013	-0066	0"023	+0021	0"041	-0040	0.005
5th series	2	+0055	0"064	-0045	0"077	+0042	0"013	-0052	0"026
6th series	32	+0080	0"000	-0079	0"010	+0046	0"023	-0047	0"013
7th series	8	+0035	0"116	-0068	0"018	+0031	0"015	+0002	0"113
		+0080		-0075		+0037		-0042	

Scale B. TABLE I.									
		50-62		62-74		74-86		86-98	
	Weight	1	2	1	2	1	2	1	2
1st series	12	+0045	0"018	+0034	0"033	-0037	0"005	-0042	0"046
2nd series	12	+0021	0"044	+0020	0"003	-0025	0"026	-0016	0"021
5th series	2	+0030	0"021	+0002	0"049	-0032	0"008	-0000	0"062
6th series	32	+0053	0"031	+0020	0"003	-0042	0"018	-0028	0"010
7th series	8	+0009	0"075	+0009	0"031	-0016	0"049	-0002	0"057
		+0038		+0021		-0035		-0024	

Scale A. TABLE II.

50-56		56-62		62-68		68-74		74-80		80-86		86-92		92-98	
	I	2	I	2	I	2	I	2	I	2	I	2	I	2	
3rd series	+ 0050	" 0'010	- 0050	" 0'010	+ 0083	" 0'057	- 0083	" 0'057	+ 0042	" 0'000	- 0042	" 0'000	- 0032	" 0'003	0'003
4th series	+ 0069	0'039	- 0069	0'039	+ 0074	0'033	- 0074	0'033	+ 0035	0'018	- 0035	0'018	- 0018	0'033	0'033
5th series	+ 0053	0'003	- 0053	0'003	+ 0092	0'080	- 0092	0'080	+ 0036	0'015	- 0036	0'015	- 0002	0'075	0'075
7th series	+ 0049	0'013	- 0049	0'013	+ 0028	0'085	- 0028	0'085	+ 0048	0'015	- 0048	0'015	- 0053	0'057	0'057
Error of interval in terms of series.	+ 0054	...	- 0054	...	+ 0061	...	- 0061	...	+ 0042	...	- 0042	...	- 0031	...	...

Scale B. TABLE II.

50-56			56-62			62-68			68-74			74-80			80-86			86-92			92-98		
Weight			I	2	I	2	I	2	I	2	I	2	I	2	I	2	I	2	I	2	I	2	
3rd series	I	+ 0050	" 0'064	- 0050	" 0'064	+ 0022	" 0'021	- 0022	" 0'021	- 0005	" 0'118	+ 0005	" 0'118	+ 0036	" 0'021	- 0036	" 0'021	- 0036	" 0'021	- 0036	" 0'021		
4th series	I	+ 0001	0'061	- 0001	0'061	+ 0006	0'021	- 0006	0'021	+ 0028	0'033	- 0028	0'033	+ 0033	0'013	- 0033	0'013	+ 0033	0'013	- 0033	0'013		
5th series	I	+ 0029	0'010	- 0029	0'010	+ 0025	0'028	- 0025	0'028	+ 0061	0'051	- 0061	0'051	+ 0041	0'033	- 0041	0'033	+ 0041	0'033	- 0041	0'033		
7th series	2	+ 0022	0'007	- 0022	0'007	+ 0009	0'013	- 0009	0'013	+ 0055	0'036	- 0055	0'036	+ 0016	0'031	- 0016	0'031	+ 0016	0'031	- 0016	0'031		
Error of interval in terms of series.		+ 0025	...	- 0025	...	+ 0014	...	- 0014	...	+ 0041	...	- 0041	...	+ 0028	...	- 0028	...	+ 0028	...	- 0028	...		

Scale A. TABLE III.

	50-53	53-56	56-59	59-62	62-65	65-68	68-71	71-74	74-77	77-80	80-83	83-86	86-89	89-92	92-95	95-98
1st series . .	+ 0032	- 0032	- 0078	+ 0078	0000	0000	+ 0052	- 0052	+ 0010	- 0010	+ 0001	- 0001	- 0055	+ 0055	- 0025	+ 0025
2nd series . .	+ 0094	- 0094	- 0042	+ 0042	- 0032	+ 0032	+ 0047	- 0047	+ 0026	- 0026	+ 0001	- 0001	- 0035	+ 0035	- 0015	+ 0015
Probable error	0'056	0'056	0'033	0'033	0'029	0'029	0'005	0'005	0'015	0'015	0'000	0'000	0'018	0'018	0'009	0'009

Scale B. TABLE III.

	50-53	53-56	56-59	59-62	62-65	65-68	68-71	71-74	74-77	77-80	80-83	83-86	86-89	89-92	92-95	95-98
1st series . .	- 0015	+ 0015	+ 0024	- 0024	- 0017	+ 0017	- 0048	+ 0048	- 0050	+ 0050	+ 0015	- 0015	- 0002	+ 0002	+ 0030	- 0030
2nd series . .	- 0032	+ 0032	+ 0020	- 0020	- 0005	+ 0005	- 0042	+ 0042	- 0051	+ 0051	+ 0022	- 0022	- 0026	+ 0026	+ 0023	- 0023
Probable error	0'015	0'015	0'004	0'004	0'011	0'011	0'005	0'005	0'001	0'001	0'006	0'006	0'022	0'022	0'006	0'006

List of Stars to be observed with Juno.

Name of Star.	Mag.	Mean R.A. 1874, Jan. 1. h m s	Mean Decl. 1874, Jan. 1. ° ' "	Name of Star.	Mag.	Mean R.A. 1874, Jan. 1. h m s	Mean Decl. 1874, Jan. 1. ° ' "
<i>a</i>	7-8	3 20 22	-0 24 8	<i>x</i>	8-9	3 5 43	-2 55 1
<i>b</i>	8-9	3 18 25	+1 31 9	<i>y</i>	6-8	3 5 15	-0 58 0
<i>c</i>	8-9	3 18 14	+0 54 6	<i>z</i>	6-7	3 5 1	-4 17 1
<i>d</i>	7	3 17 7	+0 28 0	<i>α</i>	7-8	3 3 55	-2 10 3
<i>e</i>	9	3 14 45	-0 58 7	<i>β</i>	9	3 3 7	-3 42 8
<i>f</i>	8-9	3 13 39	-2 2 9	<i>γ</i>	8	3 2 42	-4 7 6
<i>g</i>	7-8	3 13 32	+1 1 6	<i>δ</i>	9	3 2 26	-4 10 0
<i>h</i>	7-8	3 13 16	+0 44 5	<i>ε</i>	9	3 2 28	-4 4 4
<i>i</i>	7-8	3 12 38	-3 17 7	<i>ζ</i>	8-9	3 1 6	-5 52 2
<i>k</i>	5-6	3 11 54	-1 23 2	<i>η</i>	6-8	3 0 50	-2 17 1
<i>m</i>	8-9	3 9 3	-2 38 5	<i>θ</i>	8	2 57 55	-4 49 1
<i>n</i>	9	3 9 7	-0 56 6	<i>ι</i>	7	2 57 53	-5 44 0
<i>o</i>	7-8	3 8 13	-2 48 1	<i>κ</i>	8-9	2 53 48	-4 10 3
<i>p</i>	8	3 7 33	+0 16 2	<i>λ</i>	8	2 52 24	-4 42 7
<i>q</i>	9	3 6 30	-0 51 4	<i>μ</i>	8-9	2 50 26	-5 51 5
<i>r</i>	8-9	3 6 23	-3 22 7	<i>ν</i>	7	2 48 22	-5 50 4
<i>s</i>	5-6	3 6 19	-1 39 9	<i>χ</i>	7-8	2 46 58	-5 45 7
<i>t</i>	8-9	3 6 10	-3 28 3				

Date.	Star of Com- parison.	Mag.	A. R. of M. P. h m s	Decl. of M. P. ° ' "	4 Hours East.		4 Hours West.	
					Position- Angle.	Distance.	Position- Angle.	Distance.
Oct. 10	<i>b</i>	8-9	3 17 3	+1 28	80 47	31'9	67 36	33'5
	<i>g</i>	7-8	3 14 9	+1 13	240 0	49'0	244 30	45'8
Oct. 11	<i>c</i>	8-9	3 17 0	+1 3	121 20	36'0	123 43	35'5
	<i>g</i>	7-8	3 14 8	+1 6	253 50	41'5	259 29	39'3
Oct. 12	<i>c</i>	8-9	3 17 1	+0 56	99 49	35'0	92 49	36'0
	<i>g</i>	7-8	3 14 7	+1 0	272 21	36'0	279 2	35'7
Oct. 13	<i>d</i>	7	3 16 4	+0 37	132 23	28'8	123 25	27'0
	<i>h</i>	7-8	3 14 5	+0 45	264 41	36'5	272 35	35'1

It is preferable to use *c* instead of *d* if height enough.

	<i>c</i>	8-9	3 16 9	+0 50	79 55	38'9	73 44	41'2
Oct. 14	<i>d</i>	7	3 16 2	+0 30	103 55	26'2	93 1	26'8
	<i>h</i>	7-8	3 14 3	+0 38	286 52	33'5	294 43	33'9
Oct. 15	<i>d</i>	7	3 16 1	+0 24	76 59	30'0	70 7	33'5
	<i>h</i>	7-8	3 14 2	+0 32	309 6	36'4	316 4	38'0

Date.	Star of Com- parison.	Mag.	A. R. of M. P.			Decl. of M. P.	4 Hours East.		4 Hours West.	
			h	m	s		Position- Angle.	Distance.	Position- Angle.	Distance.
Oct. 16	<i>a</i>	7-8	3	17	5	-0 10	103 2	89.9	108 40	90.0
	<i>p</i>	8	3	11	1	+0 11	273 31	110.0	276 19	108.1
Oct. 17	<i>a</i>	7-8	3	17	4	-0 16	103 10	91.3	99 55	92.4
	<i>p</i>	8	3	11	0	+0 5	281 6	105.8	283 54	104.5
Oct. 18	<i>a</i>	7-8	3	17	2	-0 22	94 36	95.0	91 52	97.0
	<i>p</i>	8	3	10	8	-0 2	288 52	104.1	291 43	103.3
Oct. 19	<i>a</i>	7-8	3	17	0	-0 29	86 50	101.0	84 50	103.5
	<i>p</i>	8	3	10	5	-0 8	297 12	103.0	299 31	103.0
Oct. 20	<i>a</i>	7-8	3	16	7	-0 35	80 11	108.2	78 20	111.5
	<i>p</i>	8	3	10	3	-0 15	304 29	104.1	307 30	105.0
Oct. 21	<i>e</i>	9	3	13	7	-0 58	96 5	30.0	88 5	32.0
	<i>n</i>	9	3	10	9	-0 57	269 8	55.5	273 34	52.5

It is doubtful, however, from moonlight if *n* and *e* can be observed, if so, take

	<i>y</i>	6-8	3	8	9	-0 58	268 58	113.8	271 3	111.0	} No other star conveniently situated, parallax will depend on position-angle.
	<i>y</i>	6-8	3	3	0	-1 38	219 38	104.0	219 38	104.0	
	*										
	<i>η</i>	6 8									
Oct. 22	<i>k</i>	5-6	3	12	0	-1 17	199 35	16.5	195 5	11.5	
Oct. 23	<i>k</i>	5-6	3	11	7	-1 23	145 14	4.9	77 35	5.5	
Oct. 24	<i>k</i>	5-6	3	11	5	-1 29	48 40	13.9	44 2	18.5	
	<i>s</i>	5-6	3	8	7	-1 38	264 12	74.5	267 58	71.5	
Oct. 25	<i>f</i>	8-9	3	12	1	-1 55	111 4	47.2	105 52	48.3	
	<i>s</i>	5-6	3	8	5	-1 44	274 31	67.0	278 38	64.0	

In the event of *f* being too faint to observe in moonlight, use *i*.

	<i>i</i>	7-8	3	11	6	-2 32	163 5	96.8	160 24	94.0	
Oct. 26	<i>f</i>	8-9	3	11	8	-2 1	95 55	52.0	91 36	55.2	
	<i>s</i>	5-6	3	8	2	-1 50	286 45	60.2	291 43	59.0	

If *f* found too faint, use *i*.

	<i>i</i>	7-8	3	11	3	-2 38	155 39	88.3	152 17	86.2	
Oct. 27	<i>i</i>	7-8	3	11	0	-2 44	146 36	82.7	143 7	81.7	
	<i>s</i>	5-6	3	7	9	-1 56	300 16	56.8	305 19	57.0	
Oct. 28	<i>i</i>	7-8	3	10	7	-2 50	135 24	79.5	132 7	79.0	
	<i>a</i>	7-8	3	6	4	-2 16	277 56	77.0	281 35	75.0	

* The distance *y-η* being nearly that of Juno *y*, the change as shown by heliometric observation of the distance *y-η*, will probably be very nearly the correction to apply to observation of Juno with *y*.

Date.	Star of Com- parison.	Mag.	A. R. of M. P.			Decl. of M. P.	4 Hours East. Position- Angle.		Distance.	4 Hours West. Position- Angle.		Distance.	Care must be taken not to ob- serve the rather brighter star γ near δ .
			h	m	s		°	'		°	'		
Nov. 6	γ	8	3	3	1	-3 58	216	4	26°0	214	4	21°5	
	β	9	3	3	1	-3 50	4	37	13°5	17	31	17°4	
	δ	9	3	2	6	-4 3	212	45	17°0	215	36	12°6	
If β and δ are too faint, observe													
Nov. 7	z	6-7	3	3	9	-4 7	125	28	37°0	117	43	39°0	
	η	6-8	3	1	6	-3 7	341	16	104°0	343	41	106°0	
	δ	9	3	2	3	-4 8	160	4	5°3	113	0	5°7	
	ϵ	9	3	2	3	-4 5	279	13	3°0	9	15	3°1	
If δ and ϵ are too faint, observe													
Nov. 8	z	6-7	3	3	6	-4 11	106	16	42°2	102	10	45°2	
	θ	8	3	0	0	-4 28	234	58	79°5	236	50	74°4	
	z	6-7	3	3	2	-4 16	94	37	51°1	90	2	55°0	
Nov. 9	θ	8	2	59	7	-4 32	237	9	66°0	239	15	60°8	
	z	6-7	3	2	9	-4 20	85	22	61°9	83	41	65°8	
Nov. 10	θ	8	2	59	3	-4 36	238	59	52°5	239	6	48°0	
	z	6-7	3	2	5	-4 25	80	12	73°3	78	27	77°2	
Nov. 11	κ	8-9	2	56	9	-4 21	281	34	98°0	283	36	95°0	
	z	6-7	3	2	2	-4 29	75	29	87°0	74	48	90°1	
Nov. 12	λ	8	2	55	8	-4 41	267	42	107°5	268	52	102°8	
	θ	8	2	58	2	-4 48	75	30	13°8	83	58	10°0	
Nov. 13	θ	8	2	57	9	-4 51	318	43	4°5	4	37	5°8	
Nov. 14	ζ	8-9	2	59	1	-5 26	133	38	76°5	130	42	77°6	
	λ	8	2	54	9	-4 51	282	25	77°0	284	31	74°0	
Nov. 15	ζ	8-9	2	58	6	-5 30	125	6	80°0	122	42	81°5	
	λ	8	2	54	5	-4 55	289	27	68°8	291	46	67°0	
Nov. 16	ζ	8-9	2	58	1	-5 33	118	22	85°0	115	48	87°5	
	λ	8	2	54	2	-4 58	297	12	62°5	300	40	60°5	
Nov. 17	i	7	2	56	6	-5 31	126	40	46°4	122	41	47°4	
	λ	8	2	53	7	-5 0	308	23	56°6	310	19	55°6	
Nov. 18	θ	8	2	56	3	-5 6	54	33	58°4	55	36	62°3	
	μ	8-9	2	52	5	-5 37	249	1	72°2	249	1	67°7	
Nov. 19	θ	8	2	56	0	-5 9	56	38	69°4	57	15	72°5	
	μ	8-9	2	52	2	-5 49	249	1	61°2	249	1	57°3	
Nov. 20	i	7	2	55	6	-5 38	101	1	67°3	99	51	69°7	
	ν	7	2	50	9	-5 41	256	17	80°2	257	6	77°0	
Nov. 21	ν	7	2	55	3	-5 49	96	55	75°7	95	50	77°6	
	ν	7	2	50	6	-5 42	257	49	70°5	258	25	66°8	

Care must be taken not to observe the rather brighter star γ near δ .

Date.	Star of Com- parison.	Mag.	A. R. of M. P.			Decl. of M. P.	4 Hours East.		4 Hours West.	
			h	m	s		Position- Angle.	Distance.	Position- Angle.	Distance.
Nov. 22	ι	7	2	55	0	-5 42	93 55	83.7	92 18	86.9
	χ	7-8	2	49	6	-5 43	265 24	81.2	266 23	78.0
Nov. 23	ι	7	2	54	7	-5 43	90 28	91.3	89 49	94.2
	χ	7-8	2	49	3	-5 44	267 8	73.0	268 34	70.0
Nov. 24	ι	7	2	54	4	-5 45	89 15	100.0	88 48	103.1
	χ	7-8	2	49	0	-5 46	270 0	64.5	270 24	61.3
Nov. 25	μ	8-9	2	50	5	-5 50	218 39	5.7	187 11	3.4
Nov. 26	μ	8-9	2	50	3	-5 51	115 2	4.6	98 6	8.0
Nov. 27	μ	8-9	2	50	0	-5 52	90 52	11.8	90 0	14.3
	ν	7	2	49	0	-5 51	272 25	20.5	274 25	17.8
Nov. 28	μ	8-9	2	49	8	-5 52	87 33	19.7	85 31	21.3
	χ	7-8	2	49	0	-5 49	281 25	33.9	283 0	32.6
Nov. 29	ν	7	2	48	8	-5 52	299 52	6.3	315 48	5.2
Nov. 30	ν	7	2	48	3	-5 52	11 22	4.1	36 4	4.7

The places of the stars of comparison have been selected from the *Catalogues of the Berlin Equatoreal Star Charts*, for 2^h and 3^h A.R. by Morstadt and d'Arrest respectively, and reduced to 1874.

The A.R. and Decl. of the middle point between the planet and star (M.P.) is given for midnight at Mauritius, the position-angle and distance both for 4^h E. and for 4^h W. of the meridian at Mauritius. The places of the planet are those of the *Nautical Almanac* (Hind's Elements) reduced to the longitude of Mauritius.

Effect of Error in the Tabular Place of Venus, as deduced from Observations near the Ascending Node in 1872 and 1873, at the Royal Observatory, Greenwich, on the time of Ingress and Egress, 1874, December 8. By W. H. M. Christie, Esq.

The observed errors of Geocentric Longitude and E.P.D. must first be reduced to errors of Heliocentric Longitude, and E.P.D. by multiplying by the appropriate factors; then, on the assumption that the Heliocentric Errors at the Transit of 1874, December 8, will be the same as at the passages through the ascending node in 1872 and 1873, the errors of Heliocentric Longitude and E.P.D. previously found are to be converted into errors of Geocentric Longitude and E.P.D. for the Transit by multiplying them by the factors - 2.725 and + 2.725, respectively.

The effect of these errors in altering the distance between the centres of the Sun and *Venus*, at ingress and egress, will be found by resolving along the corresponding radii of the Sun.

The position-angles for Ingress and Egress measured from the N. point towards the E. are 45° and 345° respectively, and the angle at the Sun between the Hour Circle and the Longitude Circle is 5° ; hence the position-angles from the longitude circle for ingress and egress are 40° and 340° respectively, and the corresponding factors are :

Factor for error of Long.	Ingress + '643	Egress + '342
„ „ E.P.D.	- '766	+ '940

the positive sign indicating that the tabular time of Ingress or Egress is too late.

The following table gives the tabular errors for the Transit of *Venus*, 1874, December 8, resulting from the observations near the ascending node in 1872 and 1873 :

Date.	No. of Obs.	Error of Geocentric Longitude.	Error of Geocentric E.P.D.	Error of Heliocentric Longitude.	Error of Heliocentric E.P.D.
1872 June 28 . . .	3	" + 2'08	" + 1'47	" + 5'03	" + 3'52
1873 Jan. 18 . . .	7	+ 1'46	+ 0'58	+ 5'69	+ 0'79
1873 Sept. 14 . . .	4	+ 1'46	+ 0'36	+ 4'58	+ 0'58

Ingress.		Resulting error in tabular time of Ingress.	Egress.		Resulting error in tabular time of Egress.
Alteration of distance of centres from error of			Alteration of distance of centres from error of		
Long.	E.P.D.		Long.	E.P.D.	
"	"	"	"	"	"
-8'75	-7'34	m -7'4	-4'65	+9'00	+4'35
-9'97	-1'65	-11'62	-5'30	+2'03	-3'27
-8'08	-1'19	-9'27	-4'29	+1'46	-2'83

It is to be remarked that the numbers in the three lines of figures under the heads Ingress and Egress exhibit the errors which will be found according as we rely, for the correction of the Tabular Errors in the place of Venus, exclusively on the observations about 1872, June 28, or on those about 1873, January 18, or on those about 1873, September 14.

*Royal Observatory, Greenwich,
1874, April 22.*

Corrigendum in the "Results of Astronomical Observations at the Cape of Good Hope." Appendix D. p. 449. By Captain J. Herschel, R.E.

The subject of this correction is, the place of one of the Red Stars of which App. D contains a list. It is there entered as follows:

	^h	^m	^s		[°]	[']	["]		[']
"R.A.	21	37	19.7		N.P.D.	52	54	47	Mag. 8.

"Description: Most beautiful and extremely intense; ruby colour. Two obs."

The Sweep in which the observation supplying the above place occurs is No. 188, and was made in October 1827: the second observation has not been found.

There is, however, good reason to believe that the observation should have stood as

	^h	^m	^s		[°]	[']	["]
R.A.	21	36	19.7		N.P.D.	52	44 47.

The evidence is curious enough to be worth giving at length.

Writing on another subject, Prof. Argelander took occasion to request me to examine the original record, as he suspected the above errors. I did so, and assured him that there was no error of reduction or transcription. It happens, however, that the "Ruby Stars" R.A., is *inferred* from the note, "it is R.A. 7 beats preceding the 1st of the two stars before." These Prof. Argelander identifies, beyond doubt, as Lalande 42403* (or 79 Cygni) and 42406, the first of which, 79 Cygni, has R.A. (1830) 21^h 36^m 24^s. Consequently, the R.A. of the "Ruby Star" should be 21^h 36^m 20^s.5.

That these two stars should have been noted down at all was accidental, as appears from the remark—"two stars, 7.8 and 8^m involved in a *v.* L. milky nebula, 6' diam. *p* B" and " ? dew, on looking again, no nebula." Their entry, however, proves the error, in all three, of 1^m in R.A.; while the distraction of the attention (which may be presumed) renders probable the further mistake of 10' in N.P.D., without which the identity of the Red Star is not determined.

The above corrections are communicated at Prof. Argelander's request.

Collingwood,
1874, April 9.

Captain Herschel, in a letter dated 13th April, adds: "I had read nothing about this star in the *Monthly Notices* when I wrote the Note. I now find that it is said to have been seen, in two instances, in the place where it ought not to be! There is *no doubt* about the error in R.A.—and there is *no evidence* of error in N.P.D. Are there then *two* Red Stars, 1^m apart in R.A. and 10' in N.P.D.? It is very curious.

* This seems to be a mistake: the N.P.D. of 42403 differs by 5' from that of 79 Cygni, in the edition I have.

On the Number of Distinct Terms in a Symmetrical or Partially Symmetrical Determinant. By Prof. Cayley.

The determination of a set of unknown quantities by the method of least squares is effected by means of formulæ depending on symmetrical or partially symmetrical determinants; and it is interesting to have an expression for the number of distinct terms in such a determinant.

The terms of a determinant are represented as duads, and the determinant itself as a bicolon; viz. we write, for instance,

$$\left\{ \begin{array}{l} aa \\ bb \\ pp' \\ qq' \end{array} \right\} \text{ to represent the determinants } \left| \begin{array}{llll} aa & ab & ap' & aq' \\ ba & bb & bp' & bq' \\ pa & pb & pp' & pq' \\ qa & qb & qp' & qq' \end{array} \right|$$

This being so if the duads are such that in general $rs=sr$, then the determinant is wholly or partially symmetrical; viz., the determinant just written down, for which the bicolon contains such symbols as pp' and qq' , (each letter $p, q \dots$ being distinct from every letter $p', q', \dots$) is partially symme-

trical, but a determinant such as $\left\{ \begin{array}{l} aa \\ bb \\ cc \end{array} \right\}$ is wholly symmetrical.

A determinant for which the bicolon has m rows $aa, bb, \&c.$, and n rows $pp', qq', \&c.$ is called a determinant (m, n) ; and the number of distinct terms in the developed expression of the determinant is taken to be $\phi(m, n)$; the problem is to find the number of distinct terms $\phi(m, n)$.

Consider a determinant (m, n) where n is not $=0$; for instance, the determinant above written down, which is $(2, 2)$; this contains terms multiplied by qa, qb, qp', qq' respectively: where, disregarding signs, the whole factor multiplied by qa

is $\left\{ \begin{array}{l} bb \\ ap' \\ pq' \end{array} \right\}$, which is a determinant $(1, 2)$, and similarly the whole factor multiplied by qb is a determinant $(1, 2)$. But the whole

factor multiplied by qp' is the determinant $\left\{ \begin{array}{l} aa \\ bb \\ pq' \end{array} \right\}$, which is a determinant $(2, 1)$, and the whole factor multiplied by qq' is also a determinant $(2, 1)$.

Hence, observing that qa, qb, qp', qq' are distinct terms occurring *only* in the last line of the determinant, the number of distinct terms is equal to the sum of the numbers of distinct terms in the several component parts, or we have $\phi(2, 2) = 2\phi(1, 2) + 2\phi(2, 1)$, and so in general:

$$\phi(m, n) = m\phi(m-1, n) + n\phi(m, n-1).$$

Consider next a completely symmetrical determinant $(m, 0)$; for instance $(4, 0)$, the determinant

$$\begin{Bmatrix} aa \\ bb \\ cc \\ dd \end{Bmatrix} = \begin{vmatrix} aa & ab & ac & ad \\ ba & bb & bc & bd \\ ca & cb & cc & cd \\ da & db & dc & dd \end{vmatrix}$$

We have *first* the terms containing dd ; the whole factor is $\begin{Bmatrix} aa \\ bb \\ cc \end{Bmatrix}$, which is a determinant $(3, 0)$; *secondly*, the terms containing $ad \cdot da$, or the like combinations, $bd \cdot db$ or $cd \cdot dc$; the whole factor multiplied by $ad \cdot da$ is $\begin{Bmatrix} aa \\ bb \end{Bmatrix}$, which is a determinant $(2, 0)$; *thirdly*, the terms containing $ad \cdot db + bd \cdot da$, $= 2 ad \cdot bd$; or the like combinations $2 ad \cdot cd$ or $2 bd \cdot cd$: the whole factor multiplying the term $2 ad \cdot bd$ is $\begin{Bmatrix} cc \\ ba \end{Bmatrix}$, which is a determinant $(1, 1)$. Hence observing that $ad, bd, cd, = da, db, dc$, and dd are terms occurring *only* in the last line and column of the original determinant, it is clear that the number of distinct terms in the original determinant is equal to the sum of the numbers of distinct terms in the component parts, or that we have $\phi(4, 0) = \phi(3, 0) + 3\phi(2, 0) + 3\phi(1, 1)$; and so in general:

$$\phi(m, 0) = \phi(m-1, 0) + m\phi(m-2, 0) + \frac{m \cdot m-1}{2} \phi(m-3, 1).$$

The two equations of differences, together with the initial values $\phi(0, 0) = 1, \phi(1, 0) = \phi(0, 1) = 1, \phi(2, 0) = \phi(1, 1) = \phi(1, 2) = 2$ enable the calculation of the successive values of $\phi(m, n)$: viz., arranging these in the order

$$\begin{aligned} &\phi(0, 0) \\ &\phi(1, 0), \quad \phi(0, 1) \\ &\phi(2, 0), \quad \phi(1, 1), \quad \phi(0, 2) \\ &\phi(3, 0), \text{ \&c., \&c.} \end{aligned}$$

we calculate simultaneously the lines $\phi(m, 0), \phi(m, 1)$; and thence successively the remaining lines $\phi(m, 2), \phi(m, 3), \text{ \&c.}$: the values up to $m + n = 6$ being in fact

$$\begin{array}{ccccccc} & & & & & & 1 \\ & & & & & 1, & 1 \\ & & & 2, & 2, & 2 & \\ & 5, & 6, & 6, & 6 & & \\ & 17, & 23, & 24, & 24, & 24 & \\ & 73, & 109, & 118, & 120, & 120, & 120 \\ & 388, & 618, & 690, & 714, & 720, & 720 \end{array}$$

where the process for the first two lines is

$$\begin{array}{ll}
 5 = 2 + 2 \cdot 1 + \cdot 1 & 6 = 2 \cdot 2 + 2 \\
 17 = 5 + 3 \cdot 2 + 3 \cdot 2 & 23 = 3 \cdot 6 + 5 \\
 73 = 17 + 4 \cdot 5 + 6 \cdot 6 & 109 = 4 \cdot 23 + 17 \\
 388 = 73 + 5 \cdot 17 + \cdot 23 & 618 = 5 \cdot 109 + 23 \\
 : & :
 \end{array}$$

the larger figures being those of the two lines, and the smaller ones numerical multipliers. And then for the third line, fourth line, &c., we have

$$\begin{array}{ll}
 6 = 1 \cdot 2 + 2 \cdot 2 & 120 = 2 \cdot 24 + 3 \cdot 24 \\
 24 = 2 \cdot 6 + 2 \cdot 6 & 714 = 3 \cdot 120 + 4 \cdot 118 \\
 118 = 3 \cdot 24 + 2 \cdot 23 & : \\
 690 = 4 \cdot 118 + 2 \cdot 109
 \end{array}$$

and so on.

This is, in fact, the easiest way of obtaining the actual numerical values; but we may obtain an analytical formula. Considering the two equations

$$\begin{aligned}
 \phi(m, 1) &= m \phi(m-1, 1) + \phi(m, 0), \\
 \phi(m, 0) &= \phi(m-1, 0) + m \phi(m-2, 0) + \frac{m \cdot m-1}{2} \phi(m-3, 1);
 \end{aligned}$$

and using the first of these to eliminate the term $\phi(m-3, 1)$ and resulting terms $\phi(m-4, 1)$, &c. which present themselves in the second equation, this, after a succession of reductions, becomes

$$\begin{aligned}
 \phi(m, 0) &= \phi(m-1, 0) \\
 &+ (m-1) \phi(m-2, 0) \\
 &+ \frac{m \cdot m-1}{2} \left\{ \phi(m-3, 0) \right. \\
 &\quad + (m-3) \phi(m-4, 0) \\
 &\quad : \\
 &\quad + (m-3) \dots 3 \cdot 2 \phi(1, 0) \\
 &\quad \left. + (m-3) \dots 3 \cdot 2 \cdot 1 \right\}
 \end{aligned}$$

or, observing that the last term $(m-3) \dots 3 \cdot 2 \cdot 1$ is, in fact, $= (m-3) \dots 3 \cdot 2 \cdot 1 \phi(0, 0)$, this may be written:

$$\begin{aligned}
 2 \phi(m, 0) - \phi(m-1, 0) - (m-1) \phi(m-2, 0) &= \phi(m-1, 0) \\
 &+ (m-1) \phi(m-2, 0) \\
 &+ (m-1)(m-2) \phi(m-3, 0) \\
 &: \\
 &+ (m-1) \dots 3 \cdot 2 \cdot 1 \phi(0, 0).
 \end{aligned}$$

$$\begin{array}{ccccccc} 1 & \frac{1}{2} & \frac{3}{8} & \frac{7}{48} & \frac{25}{384} & \frac{27}{1280} & \frac{331}{46080} \end{array}$$

$$\begin{array}{ccccccc} 1 & \frac{1}{2} & \frac{3}{8} & \frac{5}{16} & \frac{35}{128} & \frac{63}{256} & \frac{231}{1024} \end{array}$$

$$\begin{array}{ccccccc} 1 & \frac{1}{2} & \frac{3}{8} & \frac{7}{48} & \frac{25}{384} & \frac{27}{1280} & \frac{331}{46080} \end{array}$$

$$\begin{array}{ccccccc} & \frac{1}{2} & \frac{1}{4} & \frac{3}{16} & \frac{7}{96} & \frac{25}{768} & \frac{27}{2560} \end{array}$$

$$\begin{array}{ccccccc} & & \frac{3}{8} & \frac{3}{16} & \frac{9}{64} & \frac{7}{128} & \frac{25}{1024} \end{array}$$

$$\begin{array}{ccccccc} & & & \frac{5}{16} & \frac{5}{32} & \frac{15}{128} & \frac{35}{768} \end{array}$$

$$\begin{array}{ccccccc} & & & & \frac{35}{128} & \frac{35}{256} & \frac{105}{1024} \end{array}$$

$$\begin{array}{ccccccc} & & & & & \frac{63}{256} & \frac{63}{512} \end{array}$$

$$\begin{array}{ccccccc} & & & & & & \frac{231}{1024} \end{array}$$

$$\begin{array}{ccccccc} 1 & 1 & 1 & \frac{5}{6} & \frac{17}{24} & \frac{73}{120} & \frac{97}{180} \end{array}$$

$$\times \text{ by } \begin{array}{ccccccc} 1 & 1 & 2 & 6 & 24 & 120 & 720 \end{array}$$

$$\begin{array}{ccccccc} 1 & 1 & 2 & 5 & 17 & 73 & 388 \end{array}$$

agreeing with the former values.

The expression of $\phi(m, 0)$ once found, it is easy thence to obtain

$$\phi(m, 1) = 1.2 \dots m \text{ coefft. } x^m \text{ in } \frac{e^{\frac{1}{2}x + \frac{1}{4}x^2}}{(1-x)^{\frac{3}{2}}}$$

$$\phi(m, 2) = 1.2 \dots m \text{ coefft. } x^m \text{ in } \frac{2e^{\frac{1}{2}x + \frac{1}{4}x^2}}{(1-x)^{\frac{3}{2}}}$$

$$\phi(m, 3) = 1.2 \dots m \text{ coefft. } x^m \text{ in } \frac{2.3e^{x + \frac{1}{4}x^2}}{(1-x)^{\frac{3}{2}}}$$

and so on, the law being obvious.

*Observations of the Eclipses of Jupiter's Satellites made at the
Observatory of Toulouse, 1874.*

(Communicated by the Astronomer Royal.)

1874.	Satel- lite.	Pheno- menon.	Obser- ver.	Instru- ment.	Toulouse M.T.			Mean Time from N.A.			Corr. to N.A.		
					h	m	s	h	m	s	m	s	s
Jan.	4	I.	Disapp.	T	A	17	0	50.1	16	54	27.7	+0	32.8
	13	I.	"	T	A	13	22	7.6	13	15	49.7	+0	28.3
	13	I.	"	P	B	13	22	3.8	13	15	49.7	+0	24.5
	13	IV.	"	T	A	18	34	23.9	18	32	17.3	-3	43.0
	* 23	III.	Reapp.	T	A	13	55	10.6	13	44	33.0	+4	48.0
	25	II.	Disapp.	P	B	16	44	41.9	16	37	57.8	+0	54.5
	25	II.	"	T	A	16	44	41.0	16	37	57.8	+0	53.6
	29	I.	"	T	A	11	36	40.1	11	30	15.4	+0	35.1
	29	I.	"	P	B	11	36	29.1	11	30	15.4	+0	24.1
	30	IV.	"	P	B	12	33	56.4	12	32	10.0	-4	3.2
	30	IV.	"	T	A	12	33	20.9	12	32	10.0	-4	38.7
	30	III.	"	P	B	14	44	1.6	14	34	38.9	+3	33.1
	30	III.	"	T	A	14	44	21.0	14	34	38.9	+3	52.5
	30	IV.	Reapp.	T	A	15	32	33.8	15	24	46.1	+1	58.1
	30	III.	"	T	A	17	51	24.6	17	41	1.7	+4	33.3
Feb.	5	I.	Disapp.	T	A	13	29	38.3	13	23	25.0	+0	23.7
	5	I.	"	P	B	13	29	43.8	13	23	25.0	+0	29.2
	* 14	I.	"	T	A	9	50	40.5	9	44	57.4	-0	6.5
	* 14	I.	"	P	B	9	50	44.0	9	44	57.4	-0	3.0
	19	II.	"	T	A	13	50	20.0	13	43	28.8	+1	1.6
	19	II.	"	P	B	13	50	18.6	13	43	28.8	+1	0.2
	19	I.	"	T	A	17	15	59.7	17	9	56.7	+0	13.4
	19	I.	"	P	B	17	16	10.7	17	9	56.7	+0	24.4
	21	I.	"	T	A	11	44	31.5	11	38	16.7	+0	25.2
	21	I.	"	P	B	11	44	39.3	11	31	16.7	+0	33.0
	* 26	II.	"	P	B	16	25	7.9	16	19	39.2	-0	20.9
	28	I.	"	T	A	13	37	36.4	15	31	41.6	+0	5.2
	28	I.	"	P	B	13	37	55.7	13	31	41.6	+0	24.5
Mar.*	2	I.	"	P	B	8	5	52.7	8	0	2.9	+0	0.2
	7	III.	"	P	B	10	33	48.3	10	24	23.0	+3	35.7
	7	I.	"	T	A	15	31	6.8	15	25	13.0	+0	4.2
	7	I.	"	P	B	15	31	14.1	15	25	13.0	+0	11.5
	23	I.	Reapp.	T	A	15	58	33.2	15	52	35.0	+0	8.6

	1874.	Satel- lite.	Pheno- menon.	Obser- ver.	Instru- ment.	Toulouse M.T.			Mean Time from N.A.			Corr. to N.A.	
						h	m	s	h	m	s	m	s
Mar.	23	I.	Reapp.	P	B	15	58	5.7	15	52	35.0	-0	18.9
	23	II.	„	T	A	16	9	25.4	16	3	51.8	-0	16.0
	23	II.	„	P	B	16	9	35.7	16	3	51.8	-0	5.7
April	1	I.	„	T	A	12	20	42.2	12	14	54.5	-0	1.9

The observations were made by M. Tisserand, and by M. Perrotin, *Aide-astronome*, whose names are referred to under the initials T and P. The aperture of the telescope employed by M. Tisserand is 11 centimètres, and of that used by M. Perrotin 15 centimètres. The longitude of the Observatory of Toulouse has been assumed to be 5^m 49^s.6 East of Greenwich. The observations marked with an asterisk were made through clouds.

Naked-eye Observation of Jupiter's Satellites.

By W. F. Denning, F.R.M.S., F.M.S.

(Communicated by the Rev. T. W. Webb, M.A., F.R.A.S.)

It may be worth recording that on the night of April 3, at about 10^h I unmistakeably saw Sat. III. and IV. of *Jupiter* with the naked eye. On the occasion referred to, these satellites were particularly well placed for such an observation, being near their greatest elongations (West) from their primary. They were seen steadily and separately several times. I also observed them in the finder (power 5) of my 10 $\frac{1}{4}$ -inch reflector and in an ordinary opera-glass (power 3); and from the remarkable ease with which they were visible, I was not surprised that unaided vision sufficed to reveal them, though previously I had been sceptical on the point, knowing it to be a disputed, albeit a well-attested one.

My first attempts to discern the satellites were unsuccessful, owing to my having taken insufficient care to cut off the planet's marginal rays, but, having accomplished this, they became perceptible. At the time, the moon was only two days past the full, but quite hidden by a bank of cumulus cloud low down in S.E. Additional weight may be attached to this observation, if I add that on several dark nights during the past winter, I distinguished 13 stars in the Pleiades, and have occasionally seen *Jupiter* in full sunshine (see *Monthly Notices*, vol. xxxiii. p. 179).

In concluding this brief paper, I may just refer to the extraordinary variations in the apparent brightness of *Jupiter's* fourth satellite. I have sometimes seen it faint and ill-defined in my 10 $\frac{1}{4}$ -inch reflector, and in smaller instruments it has been a very dim object indeed. On March 28, 1873, it was *barely visible at all* to Mr. H. C. Key, using 3 inches of aperture and power 140;

while, on the following evening, it appeared to have regained its ordinary degree of brightness (see *English Mechanic*, vol. xvii. p. 62). In fact, this satellite, though occasionally within the range of the unassisted eye, is also at times so extremely faint as to be hardly perceptible with considerable telescopic power; and there seems little doubt, therefore, that the reflective properties of its surface are very unequally distributed, and that these inequalities become strikingly manifest in certain parts of the satellite's orbit.

Cotham Park, Bristol,
1874, April 7.

On the Appearance of Round Bright Spots on Jupiter.
By W. Lassell, Esq.

(Extract from a Letter to Mr. Dunkin.)

On directing the telescope to *Jupiter* about 11 P.M. on the 23rd ult., several round bright spots almost immediately caught my eye, situated in the principal southern belt, exactly as I first saw them on March 27, 1850, of which a short description and diagram are given in Vol. x. of the *Monthly Notices*, p. 134. The atmosphere is rarely so favourable here as it was on March 23, yet I did not see the phenomena nearly so sharply as on the former occasion I refer to. I believe the appearance of these spots is very rare, as I have not seen them for many years, and the general similarity of the aspect of the planet now and then, suggests the idea that the various phases return in cycles, which I think more probable than that absolute secular changes occur in the heavenly bodies within the limit of time of any human records. I could not obtain any distinct impression of colour on the face of the planet.

Ray Lodge, Maidenhead,
1874, April 8.

The Trustees for the Johnson Memorial Prize at Oxford have proposed for the subject of the next Essay: *On the Present State of our Knowledge of the Physical Constitution and Probable Origin of Comets.*

The Essays are to be sent to the Vice-Chancellor on or before March 31, 1875.